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(71) Applicants
Dr.-Ing Rudolf Hell GMBH,
1-5 Grenzstrasse, 2300
Kiel 14, Federal Republic
of Germany
(72) Inventors
Winrich Gall
Klaus Wellendorf
(74) Agents
Baron & Warren

(54) **Production of half tone facsimile separations with optional screen angles**

(57) A method for producing half-tone printing blocks having an optional screen angle and screen line spacing by line-wise scanning of an original and recording by means of a recording element displaced over a recording medium is described.

The recording medium has co-ordinated with it an UV co-ordinate system directed in the line direction and and XY co-ordinate system turned through the screen angle, both co-ordinate systems being subdivided into areal elements from which the picture elements or half-tone dots to be produced are collated.

Notwithstanding the screen angle β, screen threshold values are associated with the areal elements of a limited scanning pattern range which corresponds to at least one mesh element of the screen which is to be recorded, as a function of their XY locus co-ordinates.

During the recording operation, the UV locus co-ordinates of the areal elements momentarily traversed by the recording element are registered on the recording medium, are recalculated in the form of the corresponding XY locus co-ordinates of the limited screen scanning range under consideration of the screen angle, and the screen threshold values associated with the XY locus co-ordinates determined are "called up".

A control signal which determines whether the areal element in question is or is not recorded on the recording medium as part of a screen element, is generated for the recording element by current comparison of the screen threshold values called up with the image signal obtained by scanning an original.

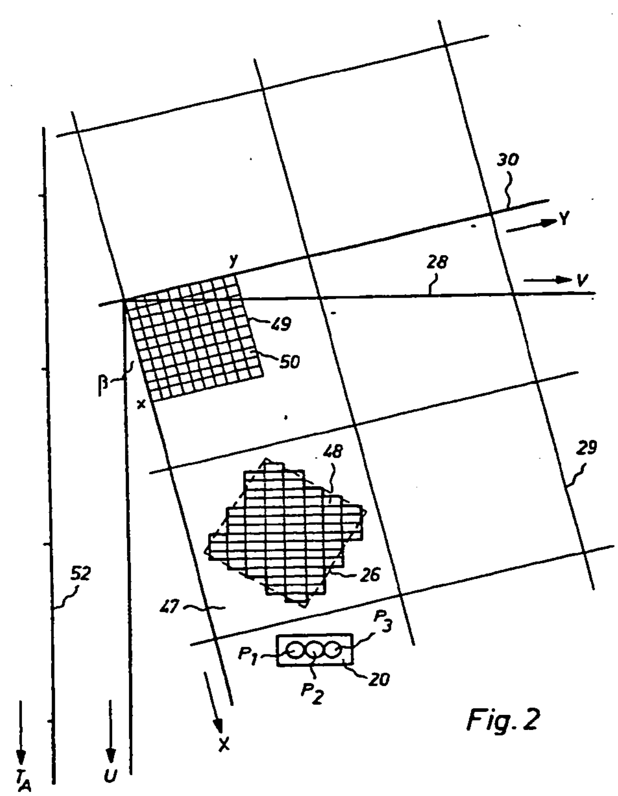

Fig. 2

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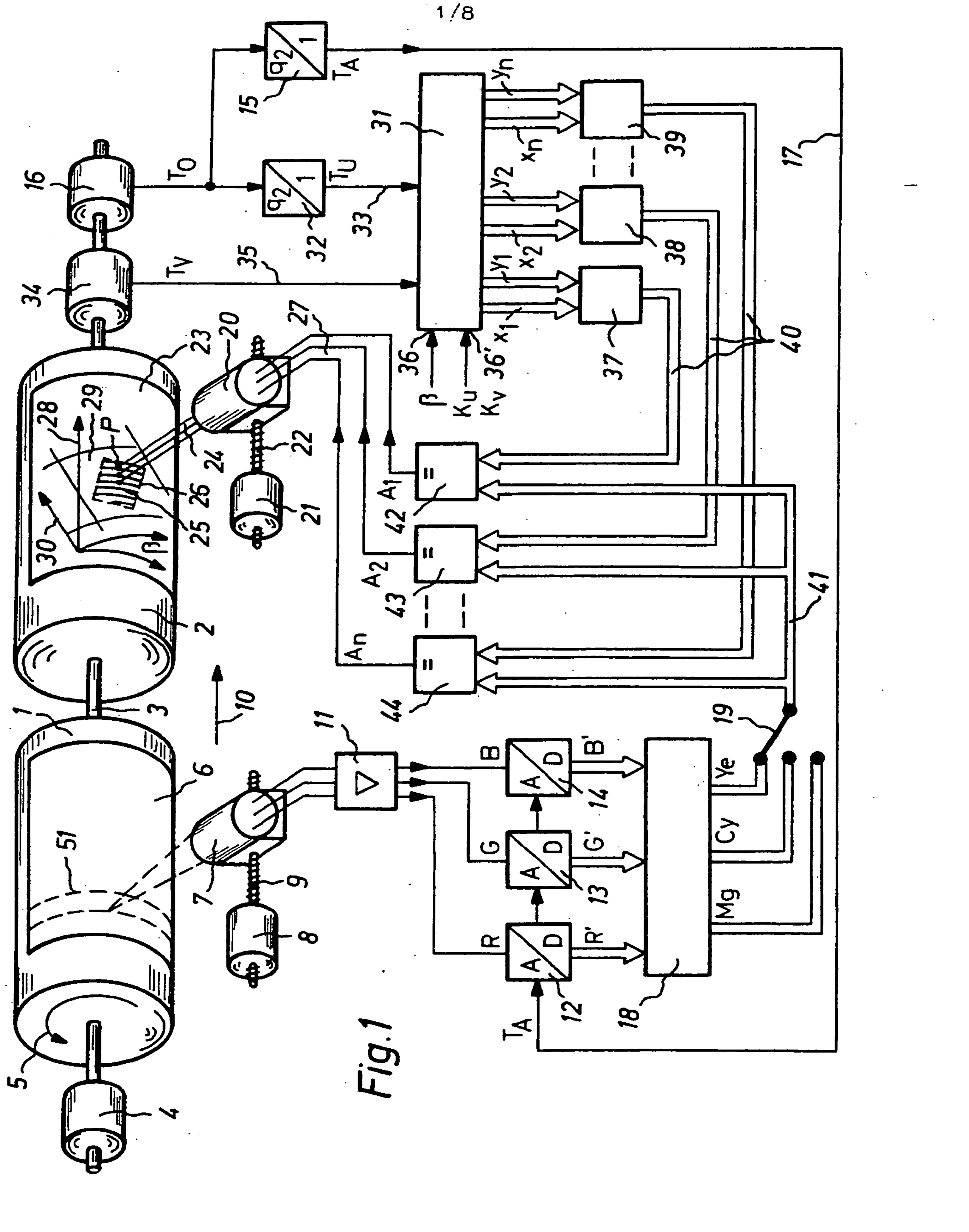

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40
41
42
43
44
51
P
β
T_O
T_U
T_V
T_A
K_U
K_V
q_2
1
x_1
y_1
x_2
y_2
x_n
y_n
A_1
A_2
A_n
=
A
D
R
G
B
R'
G'
B'
Ye
Cy
Mg

Fig.1

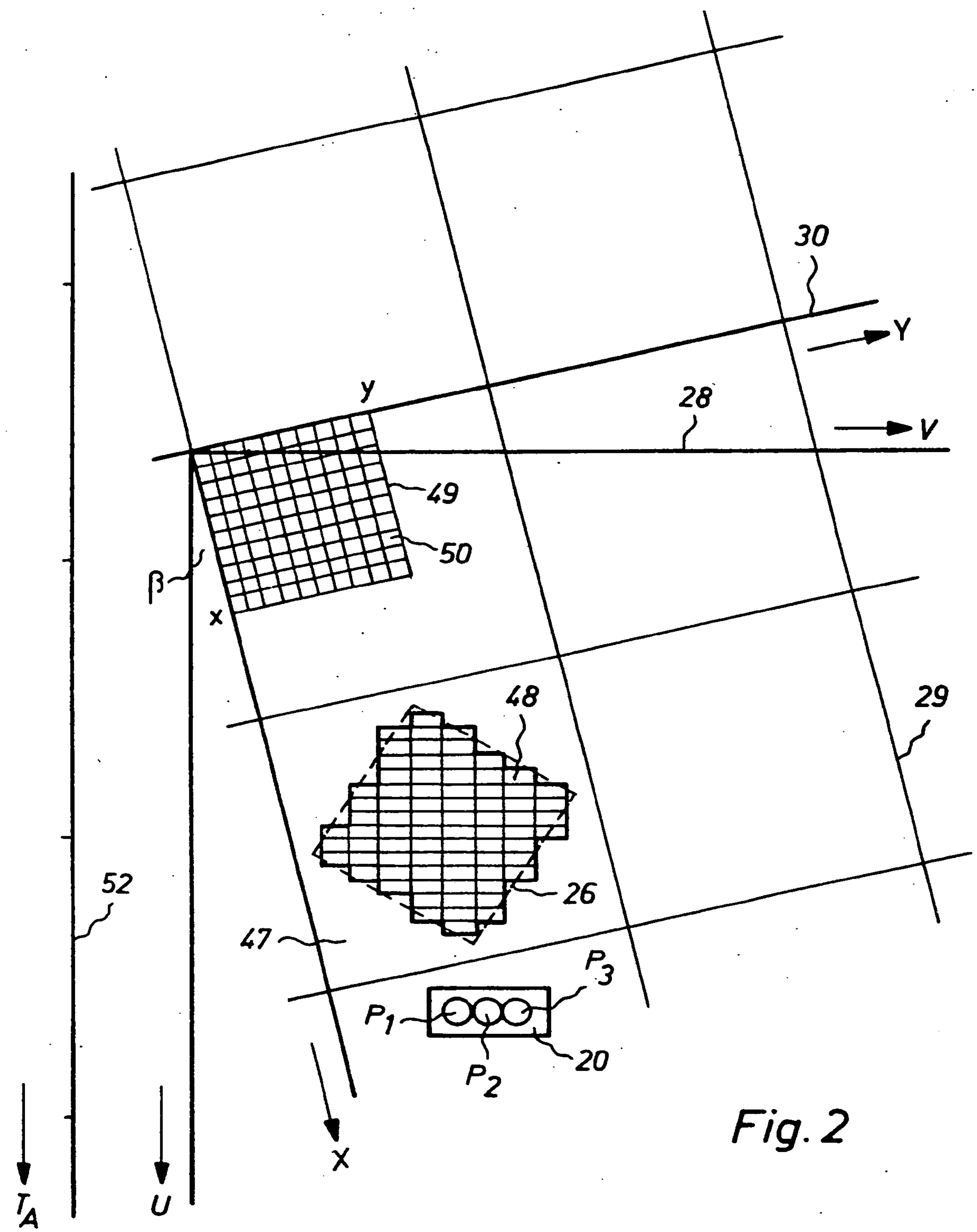


Fig. 2

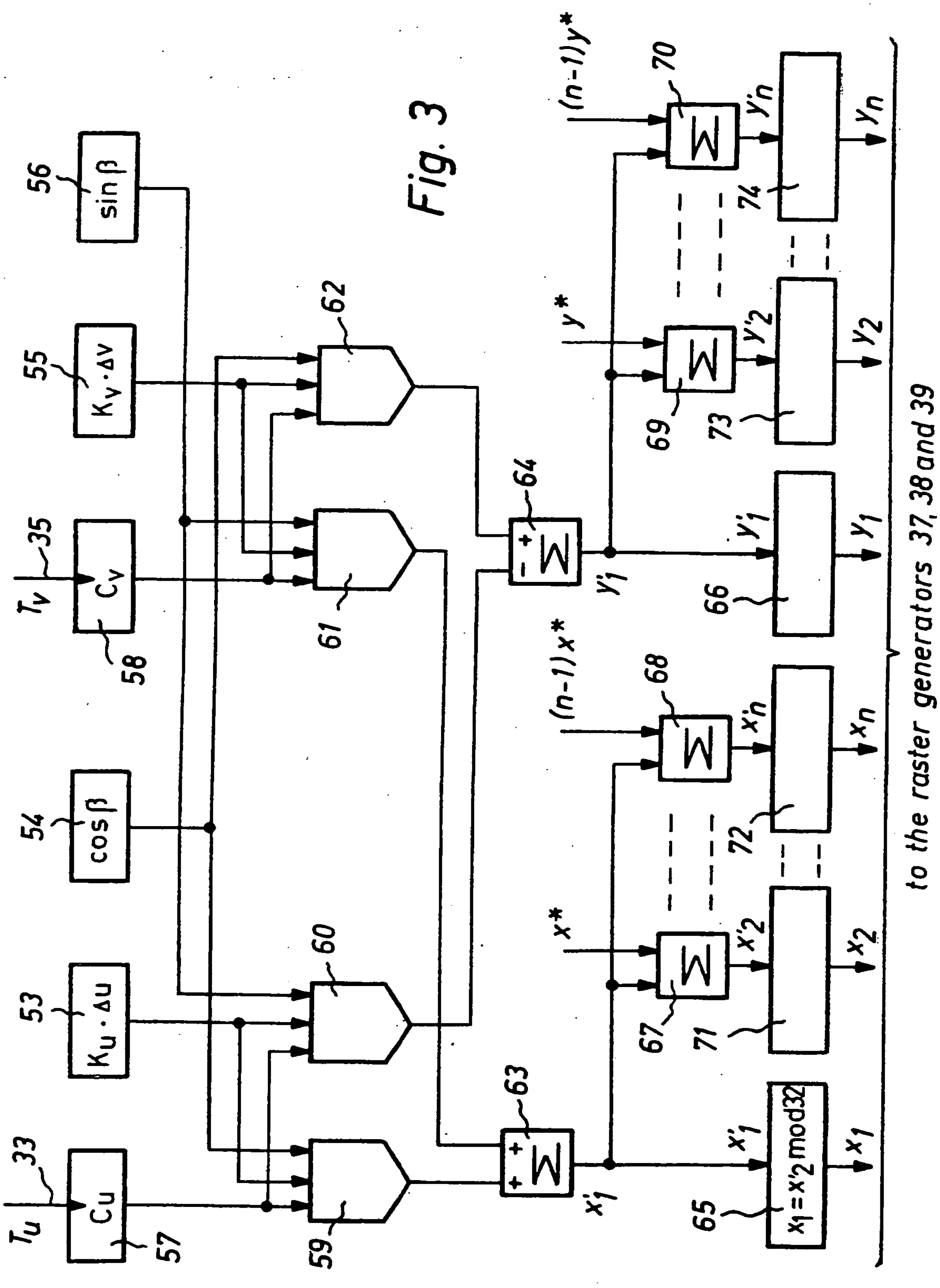

sin β
Kv·Δv
Tv
Cv
cos β
Ku·Δu
Tu
Cu
(n-1)y*
y*
(n-1)x*
x*
x1=x'2mod32
to the raster generators 37, 38 and 39

Fig. 3

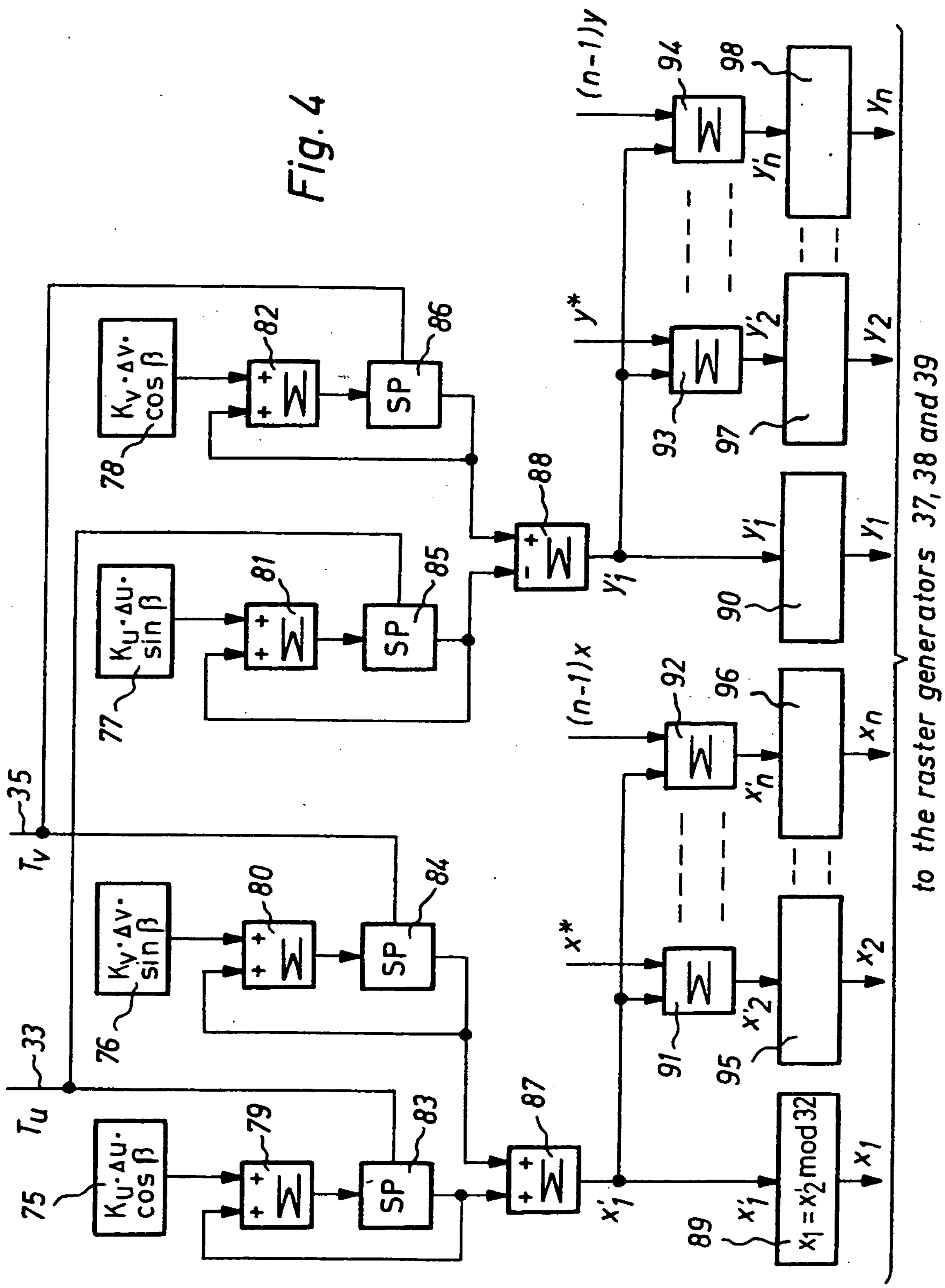
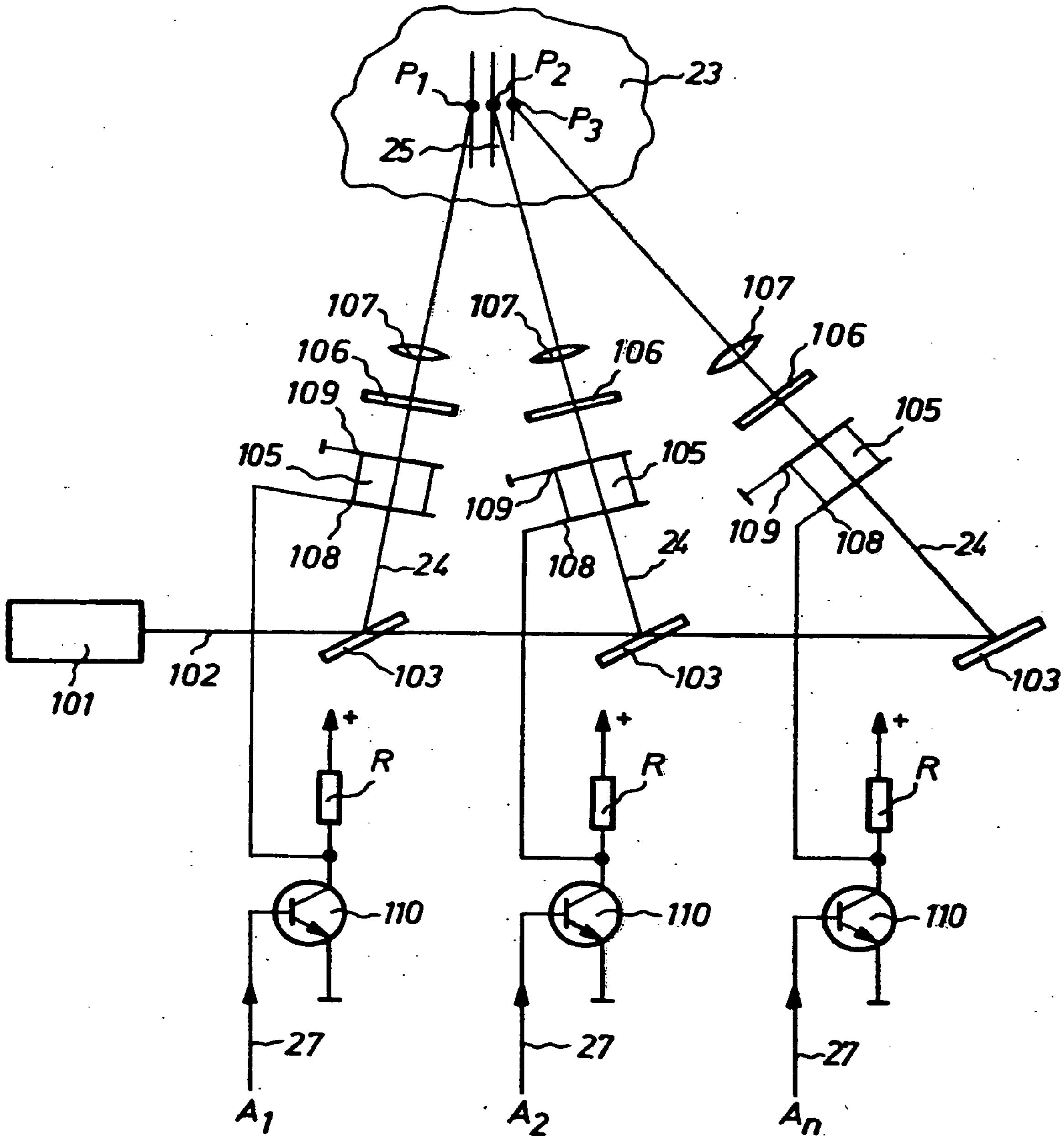

75
$K_u \cdot \Delta u \cdot \cos\beta$
76
$K_v \cdot \Delta v \cdot \sin\beta$
77
$K_u \cdot \Delta u \cdot \sin\beta$
78
$K_v \cdot \Delta v \cdot \cos\beta$
79
80
81
82
83
84
85
86
87
88
SP
Σ
T_u
33
T_v
35
x'_1
y'_1
89
$x_1 = x'_2 \bmod 32$
90
91
92
93
94
95
96
97
98
x^*
$(n-1)x$
y^*
$(n-1)y$
x'_2
x'_n
y'_2
y'_n
x_1
x_2
x_n
y_1
y_2
y_n
to the raster generators 37, 38 and 39

Fig. 4


P1
P2
P3
23
25
107
106
109
105
108
24
107
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105
109
108
24
107
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105
109
108
24
101
102
103
103
103
+
R
110
27
A1
+
R
110
27
A2
+
R
110
27
An

Fig. 5

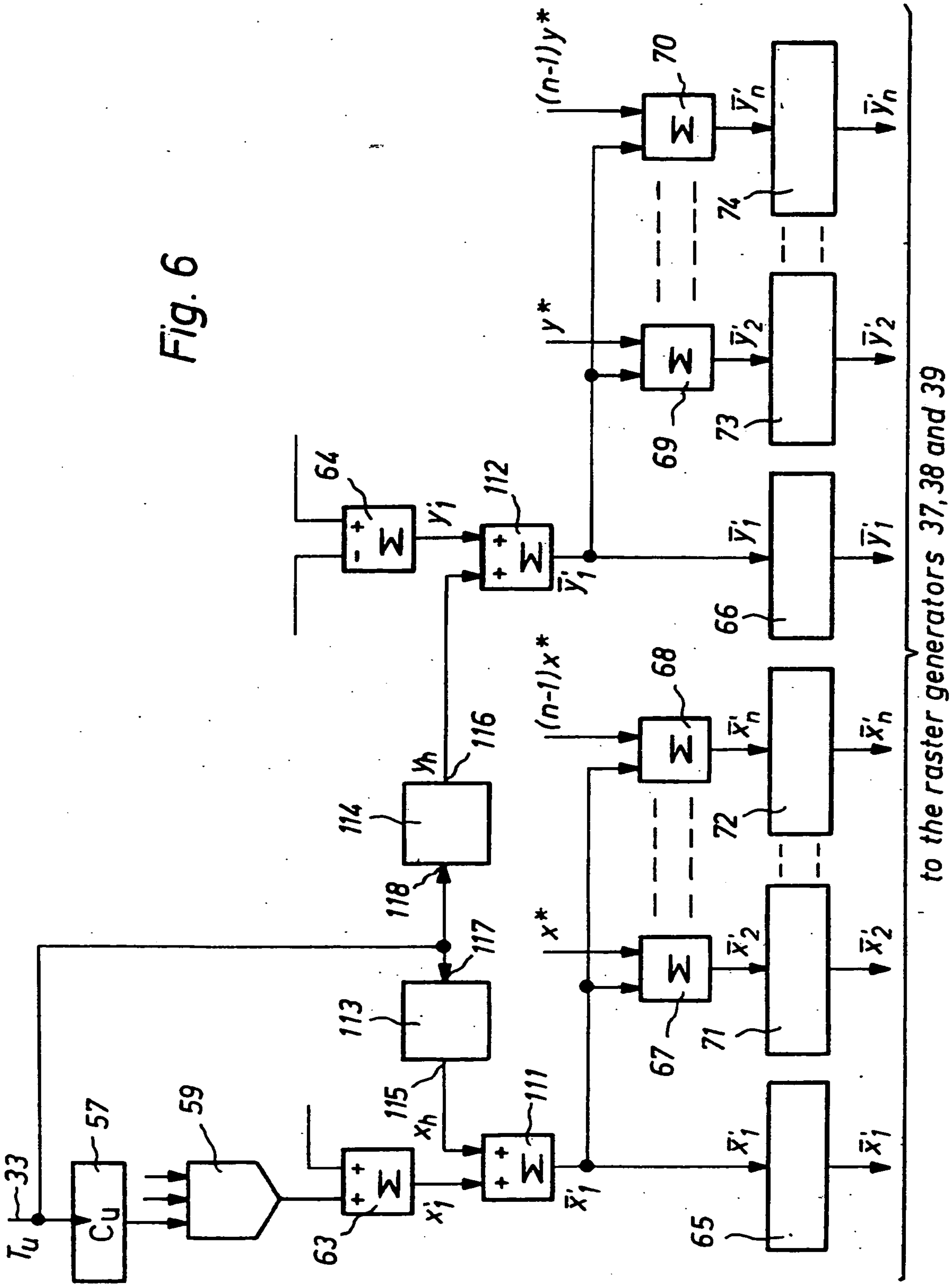


Fig. 6
T_u
33
57
C_u
59
63
64
x_1'
y_1
111
112
$\bar{x}_1'$
$\bar{y}_1'$
x_h
y_h
113
114
115
116
117
118
x^*
y^*
$(n-1)x^*$
$(n-1)y^*$
65
66
67
68
69
70
71
72
73
74
$\bar{x}_1'$
$\bar{x}_2'$
$\bar{x}_n'$
$\bar{y}_1'$
$\bar{y}_2'$
$\bar{y}_n'$
to the raster generators 37,38 and 39

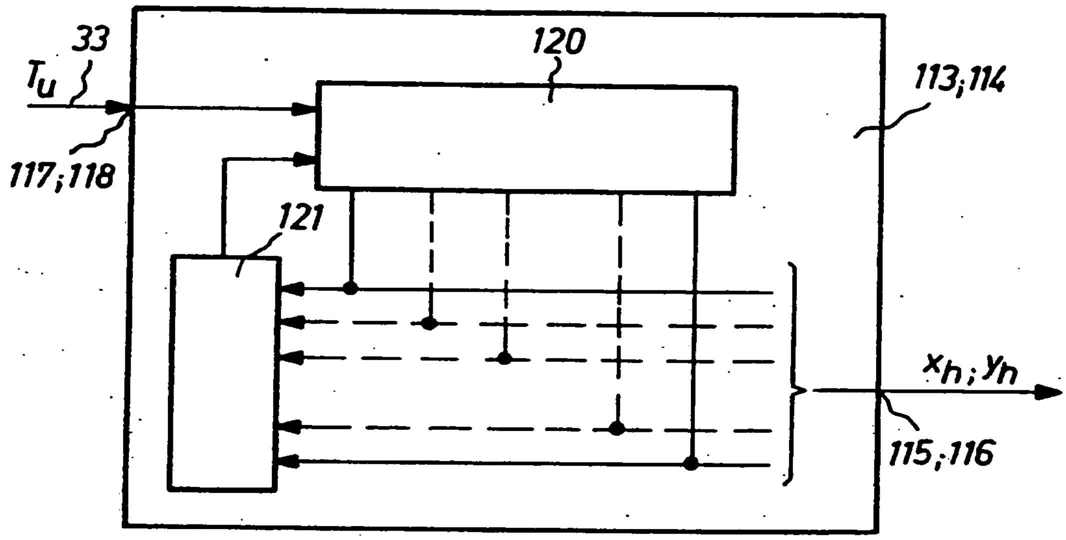

33
T_u
120
113;114
117;118
121
$x_h;y_h$
115;116

Fig. 7

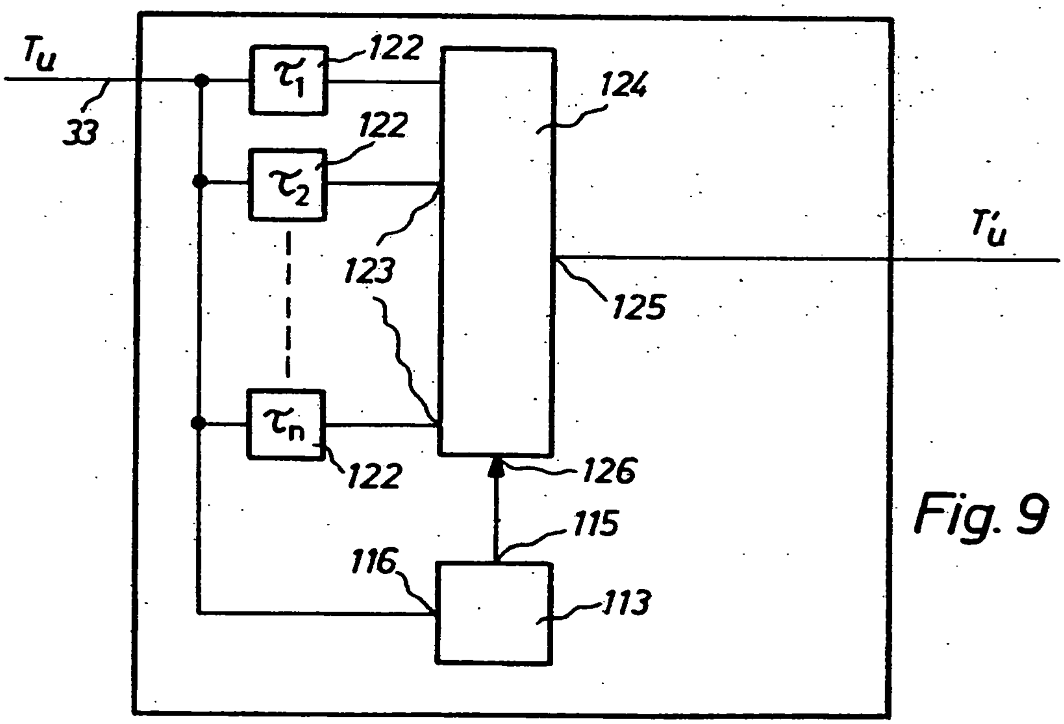
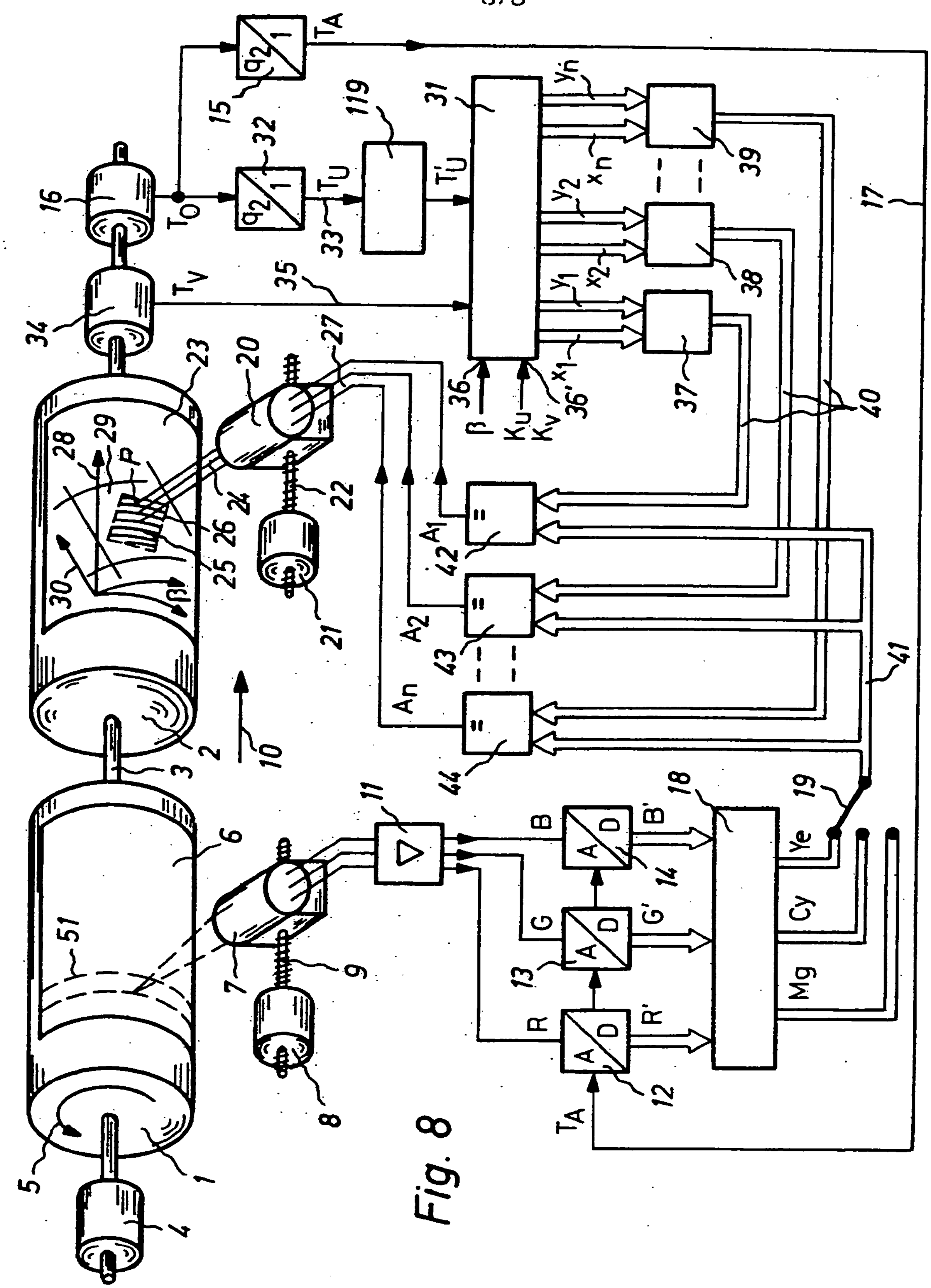

T_u
33
τ_1
122
τ_2
122
124
123
123
T_u'
125
τ_n
122
126
115
116
113

Fig. 9


TA
TO
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T'U
TV
q2/1
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32
33
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119
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16
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y1
y2
yn
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xn
37
38
39
40
17
β
KU
KV
36
36'
A1
A2
An
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43
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G'
R'
A/D
Ye
Cy
Mg
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Fig. 8

SPECIFICATION

Improvements in or relating to methods of and systems and apparatus for producing screen printing blocks

The present invention relates to a method for producing screen printing blocks of the kind having screens of optional screen angle and screen line spacing by line-wise optoelectronic scanning of an original for producing an image signal and by line-wise recording by means of a recording element displaced over and with respect to a recording medium, the latter having associated with it an orthogonal co-ordinate system subdivided into areal elements and aligned in the line direction, the locus co-ordiantes of the areal elements traversed momentarily by the recording element being determined continuously and a recording signal being generated for the recording element by current comparison of the image signal with a screen threshold signal, the recording signal controlling the recording of the individual screen dots as a configuration of areal elements in the co-ordinate system, and to a system for carrying out the method.

The inventive method is applicable for example in the case of a colour scanner for producing corrected colour separations. In the case of a colour scanner of this nature, which is known per se, a coloured original is scanned point by point and line by line by means of an optoelectronic scanning element and three primary colour signals are concomitantly obtained which are converted in a colour computer into the colour-corrected colour separations signals for recording the colour components "magenta", "cyan" and "yellow".

Recording elements in the form of light sources modulated in brightness by the colour separations signals, perform the point-by-point and line-by-line exposure of the colour components on a photosensitive recording medium. The colour separations, may be produced as half-tone colour separations for further processing in engraving machines or else as screen colour printing blocks if they are to be applied as formes for colour offset printing.

The printing in superimposition of the differently inked screen printing blocks of a colour separations for multicolour reproduction is then performed in a printing machine.

A moiré pattern is generated since it is impossible in practice to print the screen dots of the individual component colours precisely on each other. A moiré pattern of this nature makes itself felt in disturbing manner in particular upon inspecting the finished printed picture.

The obtrusiveness of moiré effects is reduced in known manner, by the fact that the screen meshes of the individual colour separations of a colour set are printed in superimposition in angularly staggered position with respect to each other. By virtue of the screen angle, the moiré phases formed are in effect either too small or too large to be noticed as troublesome by the human eye. Colour separations wherein the individual screen meshes are turned through different screen angles with respect to the recording direction, are required for a screen rotation of this kind.

Consequently, four different screen angles are needed for the four colour separations. To produce a moiré minimum, it proved to be advantageous in four-colour printing to select the screen angle $-15°$ for "magenta", the screen angle $+15°$ for "cyan", the screen angle $0°$ for "yellow" and the screen angle $+45°$ for "black". The screen angles should be adhered to very precisely since troublesome moiré effects already intervene at small angular deflections.

Other screen angles are then required complementarily if other colours are to be printed, other print media are to be applied or if different screen line spacings are to be printed one over another.

The direct application of a screen on half-tone originals in the colour scanner may for example be performed by means of a so-called contact screen application, wherein the recording beam is complementarily modulated by the density variation of a contact screen film positioned between the recording element and the recording facility, to generate the screen mesh elements.

For example British Patent Specification No. 1234975 disclosed a method for so-called "electronic screen application" wherein each screen grid element is built up in the manner of a picture pattern from individual picture elements or type or body lines. The picture patterns of the different screen mesh element sizes are stored as recording data for all tonal values and for different screen angles. The recording data are currently read out and recorded in each case, which correspond to the tonal values determined during scanning of the original, during the reproducing operation.

Whereas the instrument-related composition screen mesh in which the screen mesh elements are recorded is aligned orthogonally in the recording direction and feed direction of the implement, printing screen meshes turned in different degree with respect to the composition screen mesh are decesive for the precise positional location of the screen mesh elements on the recording medium.

What is required is to fit the different printing screen meshes to the system of the printing lines. This is particularly uncomplicated according to British Patent Specification No. 1294636 if the tangent of the screen angle is a simple rational number. A common areal element which has the fundamental structure of the screen pattern and which is repeated periodically on the recording medium in the recording and feed direction, whereby the recording operation is controllable by means of uncomplicated cadencing systems which are coupled to the displacement of the recording medium or with the feed motion of the recording element, then results for both screen systems in the case of such "rational screens".

Screen meshes having screen angles whereof the tangent is irrational, cannot be recorded according to the method hereinabove described, so that the screen angles of plus and minus 15° required for a moiré minimum cannot be established either.

A different method, whereby "irrational screens"

may also be recorded, is described in British Patent Specification No. 1493924. In this known method, XY pulse series are derived from the displacement of the recording drum and from the feed motion of the recording element, the analysis of said series determining the momentary positional locus of the recording element with respect to the recording facility in an orthogonal co-ordinate system aligned in the recording and feed direction.

The XY pulse series are converted in accordance with a predetermined function, to generate a screen signal. This function, which is periodic and bidimensional, represents the screen pattern turned through the required screen angle.

During the recording action, the screen signal and the image signal are compared continuously and the decision as to whether a screen grid element is to be or is not to be recorded at the locus characterised by XY pulse series is derived from the comparison.

The function is reproduced electrically in a function generator wherein, among others, other pulse series are initially generated by multiplication of the frequencies of the XY pulse series by particular factors, the factors being irrational or almost irrational and representing different functions of the screen angle selected for the printing operation.

The multiplication is performed by means of phase-locked loop circuits which, according to experience, have a build-up action and relatively low stability. The required screen angle may consequently be adhered to with a limited precision only, so that as already stated, troublesome moiré phenomena may appear at a particular angular deviation.

To improve the definition and printability of the screen dots, it is frequently desirable to produce different screen dot shapes or to split the screen dot into partial elements, in accordance with British Patent Specification No. 1448727.

In the method disclosed by said British Patent Specification No. 1493924, it may well be possible to produce circular or rectangular screen dots by means of different functions, but the possibilities of variations are very limited. Furthermore, some of the functions specified may be reproduced in a function generator with difficulty only, which is considered to be disadvantageous.

In the known device, the recording is produced by several partial beams situated one beside another, which are emitted from a recording element. The image signal must be compared to different screen signals, to control the partial beams. The generation of the screen signals which must take allowance for the different points of impingement of the partial beams on the recording facility, is not described in particular.

Accordingly, in a method of the kind hereinabove specified, the invention consists in that an orthogonal X-Y co-ordinate system which includes the screen angle β with the U-V co-ordinate system aligned in the line direction, and is aligned in the direction of the screen, is associated with the turned screen which is to be recorded, said screen consists of orthogonal screen mesh elements corresponding in size to the predetermined screen line spacing, and each screen mesh element consisting of the areal elements with which are associated corresponding x;y locus co-ordinates, and notwithstanding the screen angle β, a screen threshold value is associated in each case with the areal elements of at least one spurious screen mesh element of optional screen line spacing as a function of their x:y locus co-ordinates, said u;v locus co-ordinates of said areal elements alocated during current co-ordinate determination to a screen mesh element which is to be recorded and has a predetermined screen line spacing, are recalculated into the limited range of values of the corresponding x;y co-ordinates of said spurious screen mesh element, and said screen threshold value associated with each pair of co-ordinates which upon comparison with the corresponding image signal determines whether the areal element in question is or is not recorded as a part of a screen dot in the U-V co-ordinate system, is determined by means of said recalculated or converted x;y locus co-ordinates.

This method avoids or minimises the disadvantages referred to.

One advantage of the method specified consists in that any optional screen angle, i.e. a screen angle whose tangent is rational or irrational, may be set up with high precision. It is thus possible to record "rational screens" and "irrational screens". The screen angles of plus or minus 15° may preferentially also be set up, as required for a moiré minimum. The screen line spacing is concomitantly unaffected by the screen angle selected.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which show certain embodiments thereof by way of example and in which:—

Fig. 1 shows a fundamental block diagram of a colour scanner,

Fig. 2 shows an enlarged section of the recording medium,

Fig. 3 shows an embodiment of converter stage,

Fig. 4 shows another embodiment of converter stage,

Fig. 5 shows an embodiment of recording element,

Fig. 6 shows an advantageous development of the converter stage,

Fig. 7 shows an embodiment for a pseudo-random cadence generator,

Fig. 8 shows a modified form of a colour scanner, and

Fig. 9 shows an embodiment of random cadence generator.

Referring now to the drawings, Fig. 1 shows a fundamental block diagram of a colour scanner for the production of electronically screened and correct colour separations.

A scanning drum 1 and a recording drum 2 are coupled via a spindle 3 and are driven jointly by a motor 4 in the direction of an arrow 5.

A colour original 6 is clipped on the scanning drum 1 and is scanned by a point of light of a light source not shown in particular, point-by-point and line-by-line. In the case of an opaque original it is the reflected scanning beam, and in the case of a transparent original it is the transmitted scanning beam,

which reaches a scanning element n, being modulated in brightness by the pictorial content of the original 6. The colour signals R, G and B which represent the colour components of the image dots scanned, are generated in the scanning element 7 by colour separation by means of colour filters and of optoelectronic conversion of the scanning beam.

The scanning element 7 is displaced parallel to the scanning drum 1 in the direction of an arrow 10, by means of a motor 8 and a spindle 9.

The colour analogue signals, R, G, B pass from the scanning element 7 and via a post-connected amplifier 11 to A/D transducers 12, 13, 14 in which they are converted by means of a cyclic scanning sequence T_A into digital colour signals R', G' and B' having a word length of 8 bits for example, a scanned picture dot being co-ordinated with each cycle of the cyclic scanning sequence T_A.

The cyclic scanning sequence T_A is generated by frequency division in a divider stage 15 from a cyclic sequence T_o, which is generated by means of a cadence generator 16 coupled in rotation to the drums. The cyclic scanning sequence is fed to the A/D transducers 12, 13 and 14 via a conductor 17.

The digital colour signals R', G' and B' are converted in a digital corrector circuit 18 into the corrected colour separation signals Mg, Cy, Ye for recording the separations "magenta", "cyan" and "yellow".

A colour and/or graduation correction is performed in the digital corrector circuit 18, depending on the requirements of the reproduction process. A corrector circuit of this nature is described exhaustively for example in the British Patent Specification No. 1227766.

A digital memory for intermediate storage of the separation signals may also be post-connected to the corrector circuit 18, to perform a scalar change between the original and the recording in accordance with British Patent Specification No. 1095482 to record the pictorial content of the entire original and to recall or repeat the same for recording with a time lag or if appropriate at a specific locus.

In the embodiment, the digital colour separation signals Mg, Cy, Ye, reach a colour separation switch 19 whereby one of the digital colour separation signals is selected in each case for screened recording of a chromatic selection.

The invention is obviously also applicable if all the separation selections are recorded in one operation, beside each other in parallel or serially, on the circumference of the recording drum 2.

A recording element 20 is displaced by means of another motor 21 and of a spindle 22, axially along the revolving recording drum 2 in the direction of the arrow 10. The recording element 20 perform the point-by-point and line-by-line illumination of the screen dots on a photosensitive recording medium 23 which is arranged on the recording drum 2.

The recording beams 24 focussed on the recording medium 23 by the recording element 20 produce a number of exposure points P_n which by virtue of the relative displacement between the recording element 20 and the recording drum 2 also illuminate the recording medium 23 along type lines 25 extending in the circumferential direction (recording direction).

Each screen dot 26 comprises a number of such closely set type lines 25. The size and shape of a screen dot depends on the length of the type or body lines 25 or rather on the momentary period of energisation of the individual recording beams 24. The recording beams 24 may be switched on and off by recording signals A_n which are fed to the recording element 20 via conductors 27. One embodiment of recording element 20 is illustrated in Fig. 5.

It is within the scope of the invention to illuminate the type lines 25 of the screen dot 26 by means of a single recording beam 24 deflectible transversely to the recording direction.

In this case, the screen dot 26 comprises type lines extending transversely to the recording direction. The deflection of the recording beam 24 may be produced by means of an electro-acoustic deflector system, e.g. as specified in the British Patent Specification No. 1386651.

The process stages for obtaining the recording signals A_n are to be described in particular in the following.

The momentary positional locus of the exposure points P_n on the recording medium 23 is established on the recording drum 2 by means of an instrument-related U-V co-ordinate system 28 unaffected by the screen angle β whose U axis is aligned in the peripheral direction of the recording drum 2 and whose V axis is aligned in the feed direction of the scanning and recording elements. The U-V co-ordinate system 28 is subdivided into a plurality of areal elements from which the screen dots which are to be recorded are built up.

The positional locus of the screen dots 26 on the recording medium 23 is given by a screen mesh 29 in an X-Y co-ordinate system 30 which is turned through the screen angle β with respect to the U-V co-ordinate system 28.

The screen mesh 29 comprises a plurality of screen mesh elements whose size depends on the screen line spacing which is to be recorded. Each screen mesh element is built up from the areal elements which are associated with corresponding x';y' locus co-ordinates.

A spatial function $R = g(x;y)$ having a range of values limited to the spurious screen mesh element, which defines the size of the screen dots as a function of different image signal amplitudes (tonal value stages) and the screen dot shape, is preset for a spurious screen mesh element which is unaffected by the screen angle and the screen line spacing of the screen which is to be recorded. In this function, R is the screen threshold value of an areal element, and x;y are its associated locus co-ordinates in the X-Y co-ordinate system 30.

The range of values of the x-y locus co-ordinates appertaining to the preset function is restricted as compared to the range of values of the x';y' locus co-ordinates of the exposure points P_n determined upon traversal of the entire recording area.

The spatial representation of the function $R = g(x;y)$ is also referred to as a "screen hill" whose base surface fills the spurious screen mesh element and wherein a cross-sectional surface passing

through the screen hill at the level of the momentary image signal amplitude indicates the screen dot size for the tonal value in question.

In the course of reproduction, the current $x';y'$ locus co-ordinates of the exposure points in the X-Y co-ordinate system 30 are determined, converted to the limited range of values of the $x;y$ locus co-ordinates of the spurious screen mesh element, and the screen threshold value co-ordinated by means of the function is called up or invoked. The screen threshold value is compared to the image signal and the decision whether the areal element in question in the U-V co-ordinate system 28 is or is not to be recorded as part of a screen dot, is derived from the comparison.

The U and the V axes are divided into fundamental steps Δu and Δv, to determine the locus co-ordinates $u_n;v_n$ of the exposure points P_n in the U-V co-ordinate system 28. The length of the fundamental steps may differ between the axes.

The locus co-ordinates $u_n;v_n$ amount to multiples of the fundamental steps Δu and Δv.

In a first process stage, the momentary locus co-ordinates $u_n;v_n$ of the exposure points P_n are determined by current counting or summating addition of the fundamental steps Δu and Δb by means of two timing sequences T_u and T_v in a converter stage 31. The timing sequence T_u is obtained by frequency division in a divider stage 32 from the timing sequence T_o of the cadence generator 16 and is fed to the converter stage 31 via a conductor 33. A fundamental step Δu is co-ordinated with each cycle of the timing sequence T_u. The length of the fundamental step may be changed by the frequency of the timing sequence T_u and may if appropriate be adapted to the required precision.

A circumferential pulse emitter 34 which is equally coupled to the recording drum 2, generates a circumferential pulse T_v co-ordinated in each instance with a fundamental step Δv, once per revolution, i.e. after every feed step of the scanning element 7 and of the recording element 20. The circumferential pulses T_v are fed to the converter stage 31 via a conductor 35.

The locus co-ordinates $u_1;v_1$ for the first point of exposure P_1 are derived from the equation:

$$u_1 = C_u \,.\, \Delta u \qquad (1)$$
$$v_1 = C_v \,.\, \Delta v$$

Δu and Δv denoting the fundamental steps in the U-V co-ordinate system 28 and C_u and C_v denoting the number of timing pulses T_u and T_v respectively.

The pairs of locus co-ordinates for the other exposure points may advantageously be calculated from the pair of locus co-ordinates of one of the exposure points, e.g. of the first exposure point P_1. The position of the exposure points P_n with respect to each other may be optional, but the exposure points will commonly lie on a straight line.

To establish an homogenous density curve over the screen dot surface, the straight line corresponding to German Patent Application No. P 26 53 539.7 extends at an angle to the generatrix of the recording drum 2.

In this case, the mutual spacings u^* and v^* of the exposure points are constant and depend only on the structural design of the recording element 20 and on the scale of reproduction. The locus co-ordinates $u_n;v_n$ of the other exposure points P_n may consequently be calculated in accordance with the equation $u_n=u_1+(n-1)\,u^*$ and $v_n=v_1+(n-1)v^*$.

The exposure points are frequently situated on the actual generatrix of the recording drum 2, however when $u^* = 0$.

Since the function $R=(x;y)$ is preset notwithstanding the screen angle β, and the screen line spacing, the locus co-ordinates $u_n;v_n$ of the U-V co-ordinate system are currently converted into the corresponding locus co-ordinates $x'_n;y'_n$ of the X-Y co-ordinate system 30 in a second process stage, in the converter stage 31, with allowance for the screen angle β and for the different screen line spacings of the screen mesh element which is to be recorded and of the spurious screen line element.

During the conversion, the greater range of values of the locus co-ordinates $x'_n;y'_n$ arising under illumination of the entire surface of the recording medium 23, is simultaneously restricted to the limited range of values of the $x;y$ locus co-ordinates of the preset function $R=g(x;y)$. This operation will be described in particular in the following.

The conversion of the locus co-ordinates in the converter stage 31 is performed in accordance with the equations:

$$x_n = K_u.u_n.\cos\beta+K_v.v_n.\sin\beta-M_x \qquad (2)$$
$$y_n = -K_u.u_n.\sin\beta+K_v.v_n.\cos\beta-M_y$$

In the equations (2), the coefficients K_u make allowance for the different screen line spacings of the screen mesh element which is to be recorded and of the spurious screen mesh element, and the terms M_x and M_y take into account the limitation of the current $x';y'$ locus co-ordinates to the value range of the function.

The screen angle and the coefficients are preset at the programming input terminals 36 and 36′ of the converter stage 31.

Examples of embodiments of converter stage 31 are depicted in Figures 3 and 4.

At its output terminals, the converter stage 31 determines corresponding pairs of co-ordinated $x_n;y_n$ for each exposure point P_n. From the pairs of co-ordinates $x_n;y_n$, and in accordance with the preset function $R=g(x;y)$, the screen generators 37, 38 and 39 generate corresponding digital screen threshold values R_n which, like the digital colour separations signals, equally have a word length of 8 bits.

Digital comparators 42, 43 and 44 are incorporated for comparing the screen threshold values R_n on the conductors 40 to the colour separation signal selected on the colour separation switch 19 on a conductor 41.

These comparators 42, 43 and 44 generate the recording signals A_n on the conductors 27, with which the illumination of the screen dots 26 on the recording medium 23 is controlled.

A variety of advantageous possibilities is available for the structure of the screen generators 37; 38; 39.

In the embodiment, the screen generators comprise read-only storage units, in which the same function R = g(x;y) is stored in each case.

The read-only storage unit comprises a storage matrix, e.g. incorporating 32x32 storage cells for the screen threshold values. The storage cells are selectable by means of 32 *x* addresses (5 bit) and of 32 *y* addresses. In this case, the x;y value range for the function is limited to "32", i.e. to the addresses 0 to 31 in each case.

It may also be envisaged to address all the read-only memories with the x;y co-ordinate values of one of the exposure points and to obtain the different screen threshold values R for the other exposure points by making allowance for the appropriate mutual spacings u^* and v^* of the other exposure points converted into the X-Y co-ordinate system 30, when programming the individual read-only memories.

To save on read-only memories, the different pairs of x;y locus co-ordinates for the exposure points may address a single read-only memory consecutively by the time-sharing method.

The screen generators 37, 38 and 39 may equally comprise function generators which reproduce the function R = g(x;y).

In this case, the function could preferentially assume the form R=g(D.x+E.y).

In the case in which the function generator operates digitally, the function R=g(x;y) could be stored in a memory whose address input terminals have applied to them the sum (D.x+E.y). Identically, the products (D.x) and (E.y) may be stored in one or more memories, which may then be addresses direct with the x;y co-ordinate values.

In the arrangement according to Fig. 1, the feed displacement of the scanning element 7 and recording element 20 in the direction of the arrow 10, may be intermittent or continuous.

In the case of an intermittent feed, the scanning and recording actions occur around the drums along circular image lines whose mutual spacing corresponds to a feed step. By contrast, in case of a continuous feed, the scanning and recording actions occur along image lines extending helically around the drums. In this case, small errors arise during the recording operation, which in accordance with an advantageous development of the inventive principle may be cancelled in the conversion equations (2) by correction factors ($S_v.\sin\beta$) and ($S_v.\cos\beta$), "S_v" denoting the pitch of the helix and "β" again denoting the screen angle. The conversion equations then have the following form:

$$x=K_u.u.(\cos\beta+S_v.\sin\beta) + K_v.v.\sin\beta M_x \qquad (3)$$

$$y=K_u.u.(-\sin\beta+S_v\cos\beta) + K_v.v.\cos\beta M_y$$

For a clearer grasp of the screen mesh element recording, Fig. 2 shows an enlarged section of the recording medium 23 with the instrument-related U-V co-ordinate system 28 (U direction = recording direction) and with turned screen mesh 29 which is to be recorded and with respect to this the X-Y co-ordinate system 30 is aligned, the co-ordinate systems including the screen angle β.

The screen mesh element 47 of the turned screen mesh 29, comprising the screen dot 26, to a degree represents the fundamental structure of the screen pattern which is continued periodically in the X and Y directions throughout the recording surface.

The screen dot 26 comprises a number of mutually adjacent type lines 25 extending in the recording direction. Each type line 25 is built up from individual areal elements 48 which are associated with current u;v and x';y' locus co-ordinates.

A spurious screen mesh element 49 of optional screen line spacing which equally comprises a number of areal elements 50, is also shown. Each areal element 50 is associated with a screen threshold value R and with a pair of x;y locus co-ordinates, whose range of values is restricted however to the spurious screen mesh element 49.

For each areal element 48 which is momentarily traversed by an exposure point a screen threshold value appertaining to a congruent areal element 50 in the spurious screen mesh element 49 is determined in accordance with the equations (2) specified in Fig. 1, and is compared to the image signal to obtain the recording signals, during the recording operation.

Different possibilities arise for obtaining the image signal.

In the embodiment according to Fig. 1, the recording element 20 which is merely hinted at in Fig. 2, generates for example three recording beams 24 and thereby also several mutually adjacent exposure points P_n which simultaneously illuminate a corresponding number of type lines 25 during one revolution of the recording drum 2.

If three exposure points P_1 to P_3 are present, as shown in Fig. 2, and if the screen dot 26 comprises six type lines 25 (or linear tracings), the screen dot 26 has been exposed by the scanning element 7 and recording element 20 after two drum revolutions or rather feed steps. In this case, no more than two image data of the original 6 scanned on two mutually adjacent image lines 51 are available for all the linear tracings 25 of the screen dot 26. The precision of the recording may be increased if an image datum obtained from a positionally co-ordinated image line 51 is available for each linear tracing 25.

This may be accomplished in advantageous manner, in accordance with the United States Patent Specification No. 4,149,195, by the fact that a plurality of image dots which are mutually adjacent in the V direction of the UV co-ordinate system 28 are scanned simultaneously in the original 6 and that it is the image signal of the image dot whose positional locus on the original 6 corresponds to the linear tracing 25 which is just to be recorded is in each case selected for controlling the recording element.

The recording element 20 may however generate no more than one recording beam 24 and thus at the same time no more than one exposure point P_1 on the recording medium 23. In this case, one linear tracing 25 is illuminated in each case per revolution

of the recording drum 2, the scanning element 7 and the recording element 20 performing one feed step by a linear tracing width after each revolution. A image datum is thereby obtained from an image line 51 of the original 6 which is positionally co-ordinated in the V direction, for each linear tracing 25 of the screen dot 26. This method may well be very precise, but it operates very slowly.

It is obviously also possible to scan several image dots in circumferential direction for each screen dot 26.

Fig. 3 shows an embodiment of the converter stage 31 wherein the current u;v locus co-ordinates of the U-V co-ordinate system 28 are determined by counting the fundamental steps Δu and Δv and are converted in accordance with equation (2) into the co-ordinates $x_n;y_n$ for driving the screen generators 37, 38 and 39.

The values $K_u.\Delta u$ and $K_v.\Delta v$, as well as $\cos\beta$ and $\sin\beta$, are stored in storage registers 53 to 56.

The cycles T_u and T_v on the conductors 33 and 35 are counted in the counters 57 and 58. The counter levels correspond to the factors C_u and C_v. The factors are multiplied in the multiplication stages 59-62, in accordance with equations (2), and the products are then summated in the adding stages 63 and 64. The current locus co-ordinates $x'_1;y'_1$, for the first exposure point P_1 are the result as a 32-bit datum.

Since the 32 *x* addresses and 32 *y* addresses of the read-only memory are selectable in the screen generators 37, 38 and 39 by means of a 5-bit data in each case, the calculated locus co-ordinates $x'_1;y'_1$ (32-bit) are converted to the limited $x_1;y_1$ address range from 0-31 (5-bit) according to the relationship $x_1=x_1'$ mod. 32 or resp.$y_1=y'_1$ mod.32, in the stages 65 and 66. The conversion occurs by stripping or skimming off the bits of higher value.

The output signals x_1 and y_1 of the stages 65 and 66 are the pair of addresses for the exposure point P_1 for selection of the read-only memory 37.

The other pairs of addresses $x_n;y_n$ for the other exposure points P_n are determined by adding the values $(n-1)x^*$ and $(n-1)y^*$ to the calculated locus co-ordinates x'_1 and y'_1 in the adding stages 67-70, and by stripping off bits in the stages 71-74. The values x^* and y^* are calculated from the predetermined spacings u^* and v^* of the exposure points P_n.

The pairs of addresses $x_n;y_n$ for the other exposure points P_n may also be determined by adding the values $(n-1)u^*$ and $(n-1)v^*$ to the locus co-ordinates u_1 and v_1 of the first exposure point P_1 and by subsequent conversion.

Fig. 4 shows another example or embodiment of a converter stage 31 wherein the locus co-ordinates $u_n;v_n$ of the exposure points P_n are determined by summating addition of the fundamental steps *u* and *v*.

The values $K_u.\Delta u.\cos\beta$, $K_u.\Delta u.\sin\beta$, $K_v.\Delta v.\sin\beta$ and $K_v.\Delta v.\cos\beta$ of equation (2) are stored in the storage registers 75-78.

For summating addition of these values, the storage registers 75-78 are in each case connected to the first input terminals of adding stages 79-82. The adding stages 79-82 have post-connected to them other storage registers 83-86 whereof the output terminals are in each case connected by return lines to the second input terminals of the associated adding stages 79-82. The acceptance of the addition results in the storage registers 83-86 is controlled by the timing sequences T_u and T_v on the conductors 33 and 35.

The mode of operation of the adding stage 79 in combination with the storage register 83, is the following. Assuming the contents of the storage register 83 to be nil, the addendum at the secondary input terminal of the adding stage 79 is then also nil. The value $K_u.\Delta u\cos\beta$ is consequently picked up in the storage register 83 with the first cycle of the timing sequence T_u on the conductor 33. This value is fed back to the secondary input terminal of the adding stage 79 and added on thereat, so that the value $2K_u.\Delta u.\cos\beta$ is taken into the storage register 83 with the second cycle of the timing sequence T_u.

The contents of the storage registers 83 and 84 are added together in an adding stage 87, and those of the storage registers 85 and 86 in another adding stage 88. The results are the locus co-ordinates x'_1 and y'_1 for the first exposure point P_1, which are converted into the pair of locus co-ordinates $x_1;y_1$ by stripping in the stages 89 and 90.

As already described in respect of Fig. 3, determining the pairs of locus co-ordinates $x_n;y_n$ for the other exposure points P_n is performed by means of the adding stages 91-94 and by means of the stages 95-98.

Determining the pairs of locus co-ordinates for the other exposure points P_n may also be performed from the known values u^* and v^* or else by appropriate presetting of the storage registers 83-86.

Fig. 5 shows an embodiment of recording element 20.

A laser generator 101 generates a polarised light beam 102 which consecutively passes through three partially transparent mirrors 103. The recording beams 24 are deflected by reflection out of the beam 102 and are directed at the recording medium 23 by adjustment of the mirrors 103. A "twister" crystal 105, a polarising filter 106 and an objective 107 are in each case situated in the beam path of the recording beams 24. When the twister crystals 105 are not energised, the polarisation planes of the polarising filters 106 are turned through precisely 90° with respect to the polarising plane of the recording beam 24, so that the latter is neutralised.

An electrical field is generated in a twister crystal 105 by means of a control voltage between the control electrode 108 and the counterelectrode 109, which is at earth potential. The electrical field turns the polarisation plane of the recording beam 24, in such manner that the same no longer impinges on the subsequent polarising filter under the blocking angle, so that the recording beam 24 is activated.

The twister crystals 105 are thus utilised as light switches which are activated and deactivated by the digital recording signal –s A_n on the conductors 27. The recording signals A_n are converted via amplifiers 110 into the control voltages for the twister crystals 105.

Instead of the system of mirrors, a separate laser generator 101 could also be present for each record-

ing beam 24. The recording beams 24 emerging from the polarising filters 106 could also be focussed on the recording medium 23 via optical fibers.

In a modified embodiment, the recording element 20 may also consist of a line of light-emitting diodes, each individual LED being controllable by means of a recording signal A_h.

The method is applicable even if the screen dots are recorded on an appropriate radiation-sensitive medium by means of a different source of radiation.

The screen generation may be improved complementarily by storing a greater number than 32 x 32 screen threshold values in the read-only memories of the screen generators 37, 38 and 39. The improvement is advantageously accomplished even without a corresponding increase of the storage capacity, if auxiliary values whose quantites are determined in random manner, are superimposed on the unconverted or converted locus co-ordinates of one of the exposure points prior to addressing the read-only memories.

In the embodiment, these randomly selected auxiliary values x_h and y_h are added to the converted current locus co-ordinates x'_1 and y'_1 of the first exposure point P_1 according to the relationship

$$\bar{x}'_1 = x'_1 + x_h$$
$$\bar{y}'_1 = y'_1 + y_h$$

Fig. 6 shows a preferred development of the converter stage according to Fig. 3, for application of this measure. To simplify matters, only those functional groups which contribute to an understanding have been taken over from Fig. 3. The adding stages 63 and 64 are followed by complementary adders 111 and 112 wherein the auxiliary values x_h and y_h are added to the converted locus co-ordinates x'_1 and y'_1 to obtain the new locus co-ordinates $\bar{x}'_1$ and $\bar{y}'_1$. The corresponding locus co-ordinates of the other exposure points are then derived from these locus co-ordinates. Such auxiliary values may also be added to the calculated locus co-ordinates of the individual exposure points. The auxiliary values x_h and y_h are obtained in separate pseudo-random generators 113 and 114 and are fed to the corresponding adding appliances via the output terminals 115 and 116. The input terminals 117 and 118 of the pseudo-random generators 113 and 114 are timed by means of the timing sequence T_u on the conductor 33 (or by the timing sequence T_v on the conductor 35). Fig. 7 shows an embodiment of pseudo-random generator. The measures specified may evidently also be taken in the converter stage according to Fig. 4.

Fig. 7 shows an embodiment for a pseudo-random generator for generating the auxiliary values x_h and y_h.

The pseudo-random generator 113;114 substantially comprises an n-bit shift register 120 and a NOR feedback circuit 212. The input terminals 117;118 of the shift register 120 are acted upon by the timing sequences T_u and T_v, respectively. Depending on which of the output terminals of the shift reigster 120 are led back via the feedback circuit 121, a quasi-random sequence of output values which is repeated only within a considerable period, is generated at the output terminals 115;116.

A pseudo-random generator of this kind is described exhaustively in the periodical "Electronics," of May 27th 1976, at page 107.

To improve screen generation, a timing sequence T'_u whose timing intervals are randomly generated, could also be applied instead of a superimposition of auxiliary values.

Fig. 8 shows a modification of the system according to Fig. 1, in which a random cadence generator 119 is situated between the frequency divider 32 and the converter stage 31.

Fig. 9 shows an embodiment for a random cadence generator 119. The timing sequence T_u obtained in the frequency divider 32 is fed to n time-lagging stages 122 with differing delay periods τ.

The time-lagging stages 122 are connected to the input terminals 123 of a multiplexer 124 at whose output terminals 125 the random timing sequence T'_u is delivered. A pseudo-random generator 113 or respectively 114 according to Fig. 7 is connected to the control input terminal 126 of the multiplexer 124.

CLAIMS

1. A method for producing screen printing blocks of the kind comprising screens of optional screen angle and screen line spacing by line-wise optoelectronic scanning of an original to obtain an image signal and by line-wise recording by means of a recording element displaced over and with respect to a recording medium, said latter having associated with it an orthogonal co-ordinate system subdivided into areal elements and aligned in the line direction, the locus co-ordinates of the areal elements traversed momentarily by the recording element being determined continuously and a recording signal being generated for the recording element by current comparison of the image signal with a screen threshold value, the recording signal controlling the recording of the individual screen dots as a configuration of areal elements in the co-ordinate system, wherein an orthogonal X-Y co-ordinates system which includes the line screen angle β with the U-V co-ordinate system aligned in the direction, and is aligned in the direction of the screen, is associated with the turned screen which is to be recorded, said screen consisting of orthogonal screen mesh elements corresponding in size to the predetermined screen line spacing, and each screen mesh element consisting of the areal elements with which are associated corresponding x;y locus co-ordinates, and notwithstanding the screen angle β, a screen threshold value is associated in each case with the areal elements of at least one spurious screen mesh element of optional screen line spacing as a function of their x;y locus co-ordinates, said u;v locus co-ordinates of the areal elements allocated during current co-ordinate determination to a screen mesh element which is to be recorded and has a predetermined screen line spacing, being recalculated into the limited range of values of the corresponding x;y co-ordinates of the spurious screen mesh element, and the screen threshold value associated with each pair of co-ordinates which upon comparison with the corresponding image

signal determines whether the areal element in question is or is not recorded as a part of a screen dot in the U-V co-ordinate system, being determined by means of the recalculated or converted x;y locus co-ordinates.

2. A method according to claim 1, wherein the conversion of the u;v locus co-ordinates into the limited range of values for the x;y locus co-ordinates of spurious screen mesh element is performed digitally in accordance with the relationships:

$$x' = K_u.u.\cos\beta + K_v.v.\sin\beta$$
$$y' = -K_u.u.\sin\beta + K_v.v.\cos\beta,$$

the coefficients K_u and K_v making allowance for the ratio between the screen line spacing predetermined in each case and the screen line spacing of the spurious screen mesh element, and wherein the restriction of the current x';y' locus co-ordinates to the limited range of values for the x;y locus co-ordinates of the spurious screen mesh element is performed by omitting bits of higher value.

3. A method according to claim 1 or 2, wherein the current u;v locus co-ordinates are determined by counting fundamental steps (Δu; Δv).

4. A method according to claim 1 or 2, wherein the current u;v locus co-ordinates are determined by continuing summating addition of fundamental steps (Δu; Δv).

5. A method according to claim 1 or 2, wherein the u;v locus co-ordinates are determined in fundamental steps (Δu; Δv), and the corresponding x;y locus co-ordinates are calculated by continuing summating addition of constant amount $D_x = K_u . \Delta u.\cos\beta + K_v . \Delta v.\sin\beta$ (respectively; $D_y = -K_u.\Delta u.\sin\beta + K_v.\Delta v.\cos\beta$) to the previously determined locus co-ordinates in accordance with the relationship $x_{(n+1)} = x_n + D_x$ (respectively: $y_{(n+1)} = y_n + D_y$).

6. A method according to any of the preceding claims, wherein the x;y locus co-ordinates of the areal elements and the screen threshold values (R) of the spurious screen mesh elements are co-ordinated in accordance with a function $R = g(x;y)$.

7. A method according to claim 6, wherein the function has the form:

$$R = g(A.x + B.y),$$

A and B representing partial threshold values.

8. A method according to claim 7, wherein the function $R = g(A.x + B.y)$ is generated digitally and the screen threshold values (R) are stored and the associated address is formed in each case by the sum $(A.x + B.y)$.

9. A method according to claim 7, wherein the function $R = g(A.x + B.y)$ is generated digitally and the terms $(A.x)$ and $(B.y)$ of the sum are stored under the addresses *x* and *y* co-ordinated with them in each case, and the values read out are added.

10. A method according to claim 6, wherein the screen threshold values (R) of the spurious screen mesh element are stored under the addresses which correspond to the associated x;y locus co-ordinates.

11. A method according to claim 10, wherein the screen threshold values (R) are deposited in a two-dimensional storage matrix.

12. A method according to any of the preceding claims, wherein, simultaneous recording of several areal elements as parts of a screen dot, several recording beams are generated in said recording element and are controllable by separate recording signals, wherein, for obtaining the recording signals for the $x_n;y_n$ locus co-ordinate pairs of the individual recording beams (n), associated screen threshold values (R_n) are determined and compared to the image signal.

13. A method according to claim 12, wherein the screen threshold values (R_n) are determined by the time-sharing method from the individual pairs of $x_n;y_n$ locus co-ordinates.

14. A method according to claim 12 or 13, wherein the $u_n;v_n$ locus co-ordinate pairs of the other recording beams are currently obtained from the u;v locus co-ordinate pair determined for one recording beam, by adding the distance of the corresponding recording beams from the one recording beam in the U-V co-ordinate system, and the individual $u_n;v_n$ locus co-ordinate pairs are converted into corresponding $x_n;y_n$ locus co-ordinate pairs.

15. A method according to claim 12 or 13, wherein the $x_n;y_n$ locus co-ordinate pairs of the other recording beam are obtained currently from the converted x;y locus co-ordinate pair of a recording beam by adding the distance converted into the X-Y co-ordinate system of the corresponding recording beams from the one recording beam.

16. A method according to claim 14 or 15, wherein an image signal intended for simultaneous recording of several recording lines is obtained by scanning an original along a scanning line which is positionally co-ordinated with one of the recording lines, and the image signal is compared to the corresponding screen threshold values.

17. A method according to claim 14 or 15, wherein an image signal intended for simultaneous recording of several recording lines is obtained for each of the recording lines by scanning an original along positionally co-ordinated scanning lines, and the image signals are compared to the corresponding screen threshold values.

18. A method according to any of the preceding claims, wherein several image dots are scanned along a scanning line for each screen element during the scanning of an original.

19. A method according to any of the preceding claims, wherein values generated in random manner prior to determining the screen threshold values, which are smaller than the locus co-ordinate values, are superimposed on the locus co-ordinates of the areal elements.

20. A method according to claim 19, wherein the randomly generated values are additively superimposed on the current x';y' locus co-ordinates.

21. A method according to any of claims 1 to 8, wherein the fundamental steps (Δu) are counter in peripheral direction by means of a cyclic sequence (T_u) and the cycles of this cyclic sequence are generated in random manner.

22. A system for carrying out the method accord-

ing to claim 1, comprising an optoelectronic scanning element for securing an image signal, a recording element which is displaceable line-by-line with respect to a recording medium and controllable by means of a recording signal for generation of the screen mesh elements situated within the screen, a system for current determination of the locus co-ordinates of areal elements of the recording medium which are momentarily traversed by the recording element within a co-ordinate system which is orthogonal and aligned in the line direction, a screen generator for forming a screen threshold signal and a comparator stage acted upon by the image signal and by the screen threshold signal for producing the recording signal, the recording signal being arranged to control the recording of the screen mesh elements as a configuration of the areal elements in the co-ordinate system, wherein a screen generator is provided in which, notwithstanding the screen angle β, the areal elements of at least one spurious screen mesh element of optional screen line spacing have in each instance associated with them a screen threshold value as a function of their x;y locus co-ordinates within an X-Y co-ordinate system, said X-Y co-ordinate system being aligned in the direction of the screen, and being turned through the screen angle β with respect to the U-V co-ordinate system which is aligned in the direction of the lines and is formed by screen grid elements corresponding in size to the specified screen line spacing, the screen mesh elements for their part being subdivided into said areal elements, and a co-ordinate converter stage situated between the system for the current determination of the u;v locus co-ordinates and the screen generator for converting the u;v locus co-ordinates of the areal elements allotted in each instance to a screen mesh element which is to be recorded with a preset screen line spacing into the limited range of values of the corresponding x;y locus co-ordinates of the spurious screen mesh element.

23. Methods of producing screen printing blocks substantially as hereinbefore described with reference to the accompanying drawings.

24. A system and apparatus for producing screen printing blocks substantially as hereinbefore described with reference to the accompanying drawings.

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